A CSP Rehearsal Scheduler

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CS182

Fall 2017

INTRODUCTION

Scheduling tech week in the world of dance and theater is a major headache. It requires booking back-to-back rehearsals in the theater space, making the most out of the stage prior to opening night.

The producer of the Harvard Ballet Company has always made the tech week schedule by looking at a spreadsheet of everyone's availability and then through a method of trial-by-error, figuring out by hand the best time slots that work for the most people. However, one never knows if the final rehearsal schedule is optimal. Inevitably, there are always dancers and musicians who simply cannot make all their scheduled rehearsal times.

APPROACH

I aimed to make an automated tech week rehearsal scheduler that formulates tech week scheduling as a constraint satisfaction problem:

- Variables: The hour-long slot of a choreographer's rehearsal
- **Domains**: The times that the stage is open
- Constraints:
 - Hard Constraints:
 - Choreographer's availability
 - Soft Constraints (that can be relaxed if necessary):
 - Each dancer's availability
 - Non-Harvard college dancers have all their rehearsals scheduled on the same day

To find the best solution, I used:

- Depth first search
- MRV and LCV heuristic with backtracking
- Stochastic gradient descent

To determine the best schedule, for each solution I evaluated its optimality by weighting the constraints it violated among features such as cluster factor and dancer rest time.

In this project, I create a rehearsal scheduler to automate the often tedious process of making a master tech week schedule, which requires working around 20 – 30 different student schedules. My scheduler delivers the optimal solution when possible and if not, utilizes various heuristics and probabilistic methods to approximate the best solution.

I had 3 data sets to evaluate my model on, each one containing the **dancer availabilities** and **tech week schedule** of a performance by the Harvard Ballet Company:

- Oz, Fall 2016 in Farkas
- CityScapes, Spring 2017 in HDC
- In Passage, Fall 2017 in Farkas

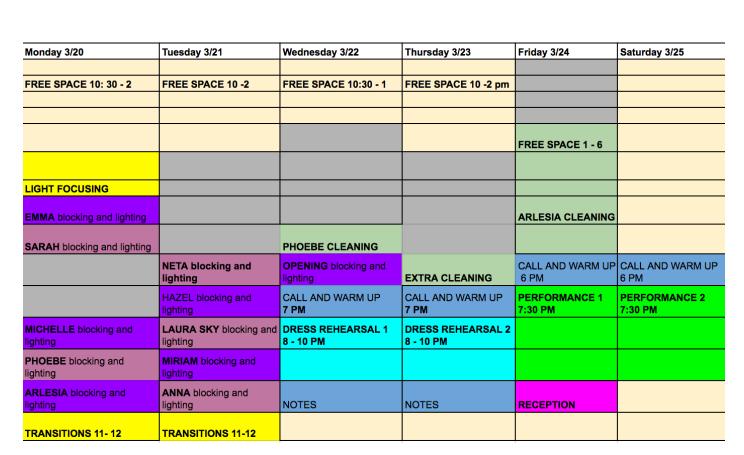


Figure 1. Tech Week schedule from CityScapes (purple = rehearsals, grey = unavailable, blue = dress rehearsal)

RESULTS

Dataset	Traditional Method	CSP Solver using DFS
Oz	Violations: 10 Score: 18	Violations: 4 Score: 6
Cityscapes	Violations: 5 Score: 22	Violations: 0 Score: 19
In Passage	Violations: 8 Score: 7	Violations: 2 Score: 1

Note: We aim to minimize the score.

The CSP solver manages to find a much better solution compared to the manual way of creating the schedule. Furthermore, it is able to produce a solution in **on average 0.003 seconds** (while in my past experience with pen and paper, the process has taken at least 1.5 hours).

Not shown: the heuristic method works very well as well, achieving similar scores to DFS.

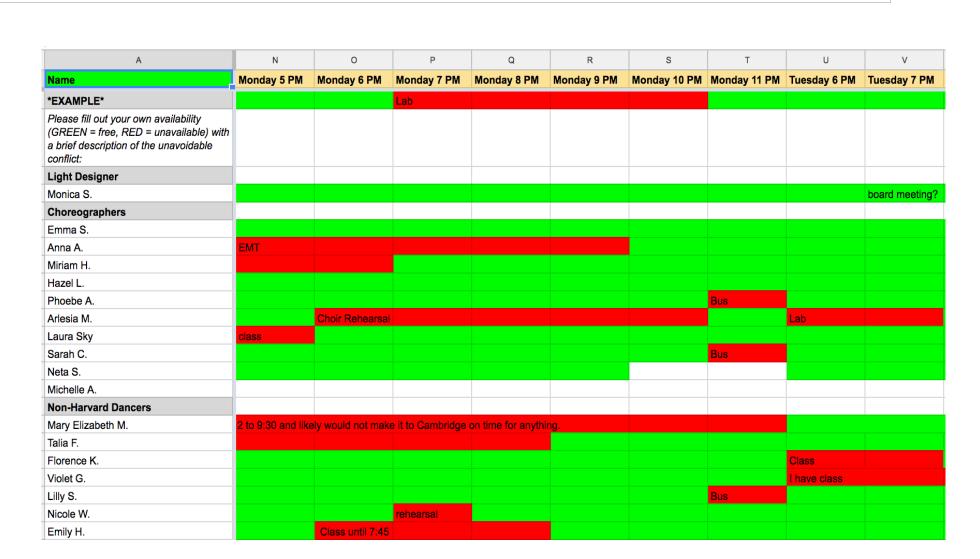


Figure 2. Dancer availabilities for the week of 3/19/17 to 3/24/17 for choreographers and non-Harvard college dancers

CONCLUSION

The automatic CSP scheduler provides many advantages over the traditional method:

- Much faster
- Finds optimal solution
- Allows for flexibility
- Provides many solutions
- Easily customizable

In the future, I would like to implement a **GUI** for this program so that producers can run the scheduler without needing the code and dancers can enter their availability via a URL. I would also like to **explore more** randomized methods, since DFS can be time-consuming. Overall, I hope my project will be a useful piece of software that the Harvard Ballet Company can use for years to come.

PROJECT RESOURCES

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